Slope Instabilities
Along the Highway 1 Corridor:
Road Condition and Hazard Potential

Highway 1 along the Big Sur Coast
From San Carpoforo Creek in San Luis Obispo County
To the Carmel River in Monterey County
SLO-1-71.4/74.3
MON-1-0.0/72.3

California Department of Transportation
District 5

September 2001

Potential Slope Instabilities in the Highway 1 Corridor:

Road Condition and Hazard Potential at Sites Between San Carpoforo Creek and Carmel Highlands

San Luis Obispo and Monterey Counties, California

Prepared for the

BIG SUR COAST HIGHWAY MANAGEMENT PLAN

SLO-001-071.4/074.3

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Introduction

The California Department of Transportation is leading a collaborative planning effort among diverse stakeholders, including state, federal, and local agencies, community organizations, and elected officials, to develop a management plan for Highway 1 along the Big Sur coast. The effort will produce the Big Sur Coast Highway Management Plan, intended to establish coordinated management of the Highway 1 corridor along this widely treasured coastline.

As part of the Coast Highway Management Plan (CHMP), the office of Geotechnical Design North conducted a preliminary site assessment along the Big Sur Coast Highway 1. The following study is to be used in conjunction with the 2001 study performed by the California Department of Conservation, Division of Mines and Geology also for the CHMP.

The study section of Highway 1 is along the central portion of the California coastline. This area has historically experienced significant disruptions from slope instabilities, coastal erosion and debris/mud flows from the slopes and drainage canyons above and below the roadway. The geologic problems encountered along the coast typically occur during heavy rainfall events.

The project study area is located on the coastal section of San Luis Obispo and Monterey Counties along a 75-mile section of Highway 1 (see Figure 1 below).

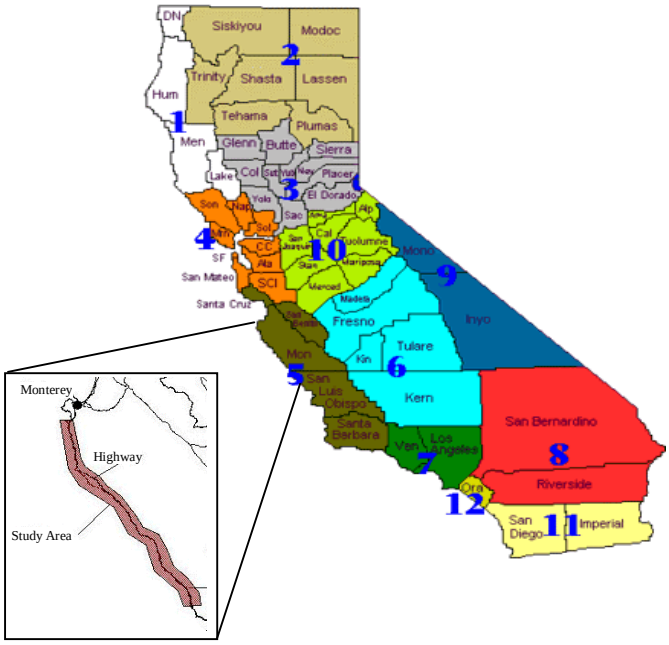

Figure 1: District boundaries of California showing the location of the study area along Highway 1 and the Big Sur coast.

The extents of the study are from postmile (PM) 71.38 at the north end of the San Carpoforo Creek Bridge in San Luis Obispo County to PM 67.34 at Yankee Point Drive in Monterey County. This study includes brief discussions, descriptions and characterizations of potential slope instability locations along the subject alignment.

The objective of the study was to identify locations along the alignment that pose existing and potential geologic problems for the roadway and to summarize site features and potential landslide affects in a tabular form. A copy of the data has been presented in Table A-1 in Appendix A. A complete set of digital photographs is presented in Appendix B. The locations of the identified existing and potential problem locations are shown in Appendix C on a set of 1:24,000 scale topographic maps and in Appendix D on a set of 1:500 scale 1998 aerial layouts.

Methodology of Study

The study consisted of several stages. The first step was to gather current and potential instability locations along the alignment office notes and storm damage records compiled and kept by the Geotechnical staff. A field reconnaissance of the listed locations was then conducted to note features and conditions of the highway. At this time additional sites were added, as they were observed and recorded. Once the field data was obtained, a database was created in both a spreadsheet and a Geographic Information System (GIS). These tools will be used by Caltrans to track and update the potential slope instability locations, as well as provide a means for data to be easily presented.

Caltrans District 5 Geotechnical Staff performed the field reconnaissance in the study area during the summer of 2000. The goal of the reconnaissance was to gather critical data from potential locations to establish a database. The database was to contain pertinent information on existing and potential slope instability locations along the study route, and to identify the relative future potential for slope instabilities. At each location a checklist was used to record the necessary information. Best estimations and assumptions were made on the types of hazards present, site geometry, site geology, relative impact to, and condition of the highway. In addition, a comprehensive set of photographs was taken for each site and the location of the sites were plotted and marked on field copies of aerial photographs.

As field data were collected it was taken back to the office for checking and assessment. The relative future potential for slope instability at individual sites and areas along the route were then classified in a landslide effects matrix. The database and associated landslide effects matrix are presented in Appendix A, Table A-1, CHMP Summary of Existing and Potential Slope Instability Site Characteristics.

The color photographs taken during the time of the study are presented in Appendix B. The photographs are keyed to the locations listed in Table A-1. Potential slope instability locations for the sites listed in Table A-1 are presented on a set of topographic maps presented in Appendix C. The maps presented here were prepared at a scale of 1:24,000 using ArcView GIS v3.2 on scanned images of USGS 7.5-minute topographic

quadrangles. In addition, Appendix D includes a set of aerial layouts containing the potential slope instability locations. The aerial layouts are presented at a scale of 1:500 using ArcView GIS v3.2 on scanned images of aerial photographs taken during 1998.

The data presented in Table A-1 were obtained from the field study conducted during the summer months of 2000, and from an ongoing inventory of unstable locations kept by District 5 Geotechnical. The identifications and characterizations are based primarily on observed conditions, existing published information, general knowledge of the area from the Geotechnical staff, and judgment. No field exploration or engineering analyses was performed to evaluate the stability of the observed features of conditions.

As part of the study an electronic database was created through Microsoft Access to monitor, assess and update conditions of the sites where potential slope instabilities exist. The database is the dynamic document of this study, while this report serves as a snapshot of the study area during the 2000-01 field study. As mentioned previously, this report is also to be used in conjunction with the (Project F99TL34) prepared in 2001 by the California Department of Conservation, Division of Mines and Geology. Project F99TL34 titled “Landslides in the Highway 1 Corridor: Geology and Slope Stability Along the Coast Between Point Lobos and San Carpoforo Creek, Monterey and San Luis Obispo Counties, California” details landslide limits, types and activity levels for the locations specified in this report.

Inventory Assessment and Implementation of Database

Data gathered from the field study and from various office notes were collected in Table A-1, found in Appendix A. The table can be used to assess and estimate the relative potential for the possibility of slope instability at individual sites along the Big Sur Highway 1 study area. The table consists of columns that contain information about the general area, type of potential unstable condition, approximate stationing at highway, hazard area characteristics, documented period of activity, notes and special conditions, landslide effects matrix, and photos. The following paragraphs provide a key to information presented in Table A-1.

General Area

The “General Area” section of the table provides a description of the roadway segment name, endpoints, postmile stationing and a specified location number. The route is subdivided into ten segments of varying length, presented in order from the south to the north. The segments were selected as to identify regions along the highway between commonly known points of interest or communities.

Within the ten segments the “Location Number” column provides identifying numerical designations for each potential slope instability location. A total of 88 individual existing and/or potential slope instability locations were identified in the study area. These

locations are sequentially numbered starting from the northbound edge of the San Carpoforo Creek Bridge at the south end of the study area.

Type of Potential Unstable Condition

The “Potential Type of Unstable Condition” section of the table describes the potentially problematic condition that was observed or documented at the site location. The condition at each site was identified as one of the following:

Landslide: Downslope movement, under gravity, of masses of soil and rock material. A landslide can be classified as rotational, translational, lateral spread or a combination.

Debris/Mud Flow: A moving mass of rock fragments, soil and mud, more than half of the particles being larger than sand size.

Rockfall: The movement of rock of any size from a cliff or other slope that is so steep that the mass continues to move down slope. Movement may be by free falling, bouncing, rolling or sliding. The fall may involve more than one rock but does not include large volumes of rock, rock avalanches, or landslides including rock.

Surface Sloughing: Shallow mass movement of soil as a result of water infiltration and surface water runoff.

Flood: Any relatively high stream or channel flow that overtops the stream or channel banks in any part of its course, covering land that is not normally under water.

Other;

The “other” category includes a group of miscellaneous conditions applicable to a few specific locations. The following terms for miscellaneous conditions appear on Table A-1.

Erosion: The wearing-away of soil and rock by weathering, mass wasting, and the action of streams, waves, wind, surface water and underground water.

Each location was identified with one or more potentially unstable conditions. Where one condition was dominant, for example an active landslide, only that condition was listed. Multiple potential conditions were listed where they were considered to be of comparable magnitude.

Approximate Stationing at Highway

The “Approximate Stationing at Highway” section describes the location along the roadway that the potential slope instability exists. For most locations, when possible, postmile stationing is given for both the beginning and ending location of the potential slope

instability. In addition, an estimate for the affected length along the highway is given in meters.

Hazard Area Characteristics

The Hazard Area Characteristic" section of the table presents geologic and geometric features of the location. Where possible information is included about the slope distance and angle of the location, primary geologic units, possibility of shallow groundwater and if the potential unstable condition extends below the highway. Descriptions and procedures of the characteristics are detailed below:

Slope Distance and Angle: The maximum height of slope above and below highway grade was measured using an electronic range finder. In addition, the average slope angle of the slope above and below roadway level was obtained using an electronic hand level.

Primary Geologic Units: Primary geologic units were noted at each location. The geologic information was obtained from the field study, published geologic maps and past experience. All of the geologic units and key terms used in the study are listed following Table A-1 in Appendix A.

Shallow Groundwater: Seepage of water and dense and green vegetation was present during the summer months.

Extends Beneath the Highway: Where the existing or potential condition extends beneath the highway.

Documented Period of Activity

The "Documented Period of Activity" section is a listing of known recent activity at the location. This information includes both natural activity and maintenance. A description of the abbreviations used in this section is shown at the end of Table A-1.

Notes and Special Conditions

The "Notes and Special Conditions" section is a listing of notes taken during the summer of 2000 field study. When possible the common name of the site is listed here. The notes describe how the potential slope instability is affecting the highway.

Landslide Effects Matrix

The "Landslide Effects Matrix" presented in Table A-1 contains our estimates and is a subjective characterization of both the road condition and the roadbed impact of existing and potential locations. The matrix consists of a classification system that uses field observation to classify the condition and impact of potential instabilities on the roadway. Priority levels are not assigned to locations in the matrix. A listing and description of the

classifications used in the table can be seen in the “note” section following Table A-1 in Appendix A.

Photographs

The “Photograph” section of the table provides identifying numbers for the photographs taken at each location. The photos were taken during the summer 2001 field study, using a digital camera. When possible two photos were taken per site (one typically looking northbound from a southern limit and one looking southbound from a northern limit). The photos can be seen in Appendix B.

References

The reference section of the table provides the map number, the topographic map and the aerial photograph of the location. In addition further references are shown when possible.

List of Preparers

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Table A-1
CHMP SUMMARY OF EXISTING AND POTENTIAL SLOPE INSTABILITY SITE CHARACTERISTICS
Highway 1-San Carpoforo to the Carmel River Bridge

General Area		Type of Potential Unstable Condition						Approximate Stationing at Highway[1]			Hazard Area Characteristics				Documented Period of Activity	Notes and Special Conditions[5]	Landslide Effects Matrix[6]		Photos	References[7]
Segment Name, Endpoints and Stationing	Loc. No.	Landslide	Debris Flow/Mudflow	Rock Fall	Surface Sloughing	Flood	Other	From	To	Along Highway Length (meters)	Slope Distance, Angle[2]	Primary Geologic Units[3]	Shallow Ground-water[4]	Extends Beneath Hwy			Road Condition	Roadbed Impact		
San Luis Obispo County Highway 1	1	X						PM 71.4	PM 71.4	71	50m, 28° Below	KJf		X	2/98 EO 2/00 ER	*Stabilization trench w/subsurface drainage. Constructed 2/2000. Road repaved, cracking in adjacent S. slope.*	NP	B	1, 2	Topo map 1 Aerial map 1
San Carpoforo Creek Bridge to San Luis Obispo/Monterey County Line	2	X						PM 71.7	PM 71.7	29	30m, 40° Below	KJf		X	1999-00 (Patched)	*Cracking in roadway. Recently patched, but cracking extends beyond patches*	P	OL	3, 4	Topo map 1 Aerial map 1
PM 71.38 to 74.32	3	X		X				PM 73.0	PM 73.0	27	30m, 44° Above/ 160m, 40° Below	Old Landslide, (Q_{los}) Q_{al}, KJf		X	1998-99 1999-00 (debris in catchment)	**(Ragged Point)** *Cut slope failure in Q_{ols}, Q_{al} and erosion below road to SB EP of Q_{ols}, KJf.*	N/A	A/B	5, 6	Topo map 1 Aerial map 2
	4	X				X	X	PM 73.21	PM 73.21	22	47m, 40° Below	Fill		X	2/98 EO	*Slope eroded by overtopping drainage. EO with geogrid? regraded. Slight cracking in center of SB lane.*	NP	OL	7, 8	Topo map 1 Aerial map 3
	5	X						PM 73.30	PM 73.30	27	19m, 33° Below	Fill		X	1999-00 (Patch)	*Sag and cracking across SB and into NB lane at S. extent of slide. No definitive boundary at N. end of slide. Low spot in NB ditch.*	P	TL	9, 10	Topo map 1 Aerial map 3
	6							PM 73.35	PM 73.35	40	18m, 30° Below	Fill	X	X	1999-00 (Patch)	*Cracking in SB lane extending into NB lane. NB lane recently patched. No visible end of slide on south side, but may continue to drainage culvert on NB shoulder.*	P	TL	11	Topo map 1 Aerial map 3
	7	X						PM 73.73	PM 73.86	210	43m, 39° Below	Fill		X	2/98 EO	*Cracking in road into NB lane. Cracking also along shoulder. Recently patched.*	OP	TL	12 to 14	Topo map 1 Aerial map 3
Monterey County Highway 1	8	X						PM 0.08	PM 0.08	22	34m, 41° Below	Fill	X	X		*Slight Cracking in Road 3/4 into SB Lane. Very Green Vegetation (7/17/00)*	NP	OL	15, 16	Topo map 1 Aerial map 3
San Luis Obispo/Monterey County Line to Soda Springs	9	X	X					PM 0.66	PM 0.73	117	40m, 39° Below	Fill, Colluvium	X	X	2/98 EO 2/00 ER	*Slide was repaired after 2/00 storms. Crib Wall constructed w/ a rock slope buttress supported by rock nets.*	NP	B	17, 18	Topo map 1 Aerial map 4

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General Area		Type of Potential Unstable Condition						Approximate Stationing at Highway[1]			Hazard Area Characteristics				Documented Period of Activity	Notes and Special Conditions[5]	Landslide Effects Matrix[6]		Photos	References[7]
Segment Name, Endpoints and Stationing	Loc. No.	Landslide	Debris Flow/Mudflow	Rock Fall	Surface Sloughing	Flood	Other	From	To	Along Highway Length (meters)	Slope Distance, Angle[2]	Primary Geologic Units[3]	Shallow Ground-water[4]	Extends Beneath Hwy			Road Condition	Roadbed Impact		
PM 0.00 to 3.70	10	X						PM 1.44	PM 1.51	113	60m, 35° Below	Fill over KJf		X	1/99 Patch 2/00 Failure	**(Forest Boundary Slide)** *One way traffic only (7/17/00) after 2/2000 storms. Traffic light installed. Crown of slide extends to center line of road. Repair to be viaduct, in Fall 2000.*	OP	OL	19, 20	Topo map 1 Aerial map 4
	11	X			X			PM 1.62	PM 1.64	70	83m, 40° Above	KJf					NP	A	21, 22	Topo map 1 Aerial map 4
	12	X				X		PM 2.04	PM 2.08	60	24m, 43° West/ 12m, 44° East	Fill	X	X	1998-99 Patch 1999-00 Patch	*AC patch placed periodicly. 4cm sag along CL in SB lane. No cracking visible in roadway. Fill across drainage.*	OP	TL	23, 24	Topo map 1 Aerial map 4
	13			X				PM 2.56	PM 2.76	300	60m, 36° Above	KJf				*NB and SB lanes pitted from rockfall*	N/A	A		Topo map 1 Aerial map 5
	14	X						PM 2.71	PM 2.76	80	34m, 40° Below	Fill	X	X		*Slide is in two segments (one N. and one S.) N. portion has cracking into SB lane. S. portion has cracking to CL. Sag in road between N. and S. portions.*	NP	OL	25, 26	Topo map 1 Aerial map 5
	15	X						PM 2.85	PM 3.05	350		KJf, Qols	X	X		**(C44-100 Cattle U.C.)** *Part of very large ancient landslide. 6cm sag across both lanes at the N. end. No cracking visible in roadway at S. end. Sag in road noticeable at S. end of slide. Recently patched at S. end. Painted marks in road indicate sag locations.*	P	A/B	27, 28	Topo map 1 Aerial map 5
Monterey County Highway 1	16	X						PM 3.70	PM 3.76	125	65m, 35° Below	Fill over KJf	X	X	1/99 EO 2/00 EO	**(Soda Springs)** *Slope recently repaved. Compacted fill placed for EO.*	NP	TL	29, 30	Topo map 1 Aerial map 6
Soda Springs to Villa Creek Bridge	17	X						PM 4.60	PM 4.61	21	33m, 38° Below	KJf, Fill	X	X	1/99 EO 1999-00 Patch	*Guardrail and N. end of crib wall effected, fill placed in 98-99. 3cm sag in roadway. Offset since 1998 = 1m.*	OP	OL	31, 32	Topo map 2 Aerial map 6

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General Area		Type of Potential Unstable Condition						Approximate Stationing at Highway[1]			Hazard Area Characteristics				Documented Period of Activity	Notes and Special Conditions[5]	Landslide Effects Matrix[6]		Photos	References[7]
Segment Name, Endpoints and Stationing	Loc. No.	Landslide	Debris Flow/Mudflow	Rock Fall	Surface Sloughing	Flood	Other	From	To	Along Highway Length (meters)	Slope Distance, Angle[2]	Primary Geologic Units[3]	Shallow Ground-water[4]	Extends Beneath Hwy			Road Condition	Roadbed Impact		
PM 3.7 to 7.07	18	X						PM 4.81	PM 4.84	38	30m, 41° Below	Fill, KJf	X	X	1999-00 (Patch)	*Cracking visible at ends of scarp, but not middle. Recently patched.*	P	OL	33, 34	Topo map 2 Aerial map 6
	19	X						PM 5.10	PM 5.10	50	80m, 38° Below	Fill, Qols	X	X	1/99 EO	*Cracking into and out of roadway. Green vegetation on slope. 1998 repair with fill.*	P	OL	35, 36	Topo map 2 Aerial map 7
	20	X						PM 5.20	PM 5.20	50	60m, 35° Below	Fill	X	X		*Scrap noticeable, cracking in roadway discontinuous, drainage crossing.*	NP	OL	37, 38	Topo map 2 Aerial map 7
	21							PM 6.37	PM 6.40	50	25m, 38° Below	Old Landslide, Qols, Fill		X		*S. end has cracking and sag visible across roadway.*	NP	A/B	39, 40	Topo map 2 Aerial map 7
	22	X						PM 6.70	PM 6.89	215	40m, 22° Below	Fill, KJf	X	X	1/99 Frequent	**(Gray Slip)** *Arcuate cracking at apex of turn extending 3/4 into SB lane. Roadway is approx. midway between headscarp and toe of slide at ocean.*	NP	A/B	41, 42	Topo map 2 Aerial map 8
Monterey County Highway 1 Villa Creek Bridge to Willow Springs Maintenance Station **PM 7.07 to 10.42**	23						X	PM 7.67	PM 7.78	215	32m, 45° Below	Fill		X		**(Alder Creek)** *Shore erosion of fill supporting lane.*	N/A	OL	43, 44	Topo map 2 Aerial map 8
	24	X						PM 8.22	PM 8.51	465		KJf	X	X	Frequent 2/98 ER	**(Duck Pond)** *Periodic surges in wet years, moves several meters or debris flows each event.*	OP	TL	45, 46	Topo map 2 Aerial map 24
	25	X		X				PM 8.70	PM 8.80	220	49m, 46° Above	KJf	X			*Landslide in cut above roadway. Water seeping out of base at N. end.*	N/A	A	47, 48	Topo map 2 Aerial map 9
	26	X						PM 8.97	PM 8.97	35	60m, 42° Below	KJf	X	X		*Recently patched. Sag in SB lane. Cracking only visible at edges of ETW. Spring and standing water on NB shoulder.*	OP	TL	49, 50	Topo map 2 Aerial map 9
	27	X						PM 9.40	PM 9.58	300	106m, 16° Above/ 33m, 38° Below	Fill over Old Landslide (Qols), KJf		X		*Cracking and sag visible across roadway at N. end of slide. No cracking visible at S. end of slide, but drop-off evident.*	NP	A/B	51, 52	Topo map 2 Aerial map 10
	28						X	PM 10.24	PM 10.26	20	32m, 40° Below	KJf			1/97 EO 2/98 ER	**(Gorda)** *Culvert at N. end causing erosion, landslide and debris flows. Mitigated with tieback wall.*	N/A	B	53, 54	Topo map 3 Aerial map 10

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Segment Name, Endpoints and Stationing	Loc. No.	Landslide	Debris Flow/Mudflow	Rock Fall	Surface Sloughing	Flood	Other	From	To	Along Highway Length (meters)	Slope Distance, Angle[2]	Primary Geologic Units[3]	Shallow Ground-water[4]	Extends Beneath Hwy			Road Condition	Roadbed Impact		
	29	X						PM 10.36	PM 10.36	83	28m, 40° Below	Qols, Fill		X		**(Willow Springs)** *Patched at S. end. Sag at N. end w/ cracking across roadway.*	OP	A/B	55, 56	Topo map 3 Aerial map 10
	30							PM 10.50	PM 10.69	300	Limits Not Visible	Qols, KJf		X		*Old Landslide, S. limits only visible. Lateral scarp visible through Maint. Sta.*	P	A/B	57, 58	Topo map 3 Aerial map 11
Monterey County Highway 1	31	X						PM 11.80	PM 11.88	150	55m, 40° Below	KJf	X	X	Frequent 2/98 EO 1/99 EO	**(Willow Creek)** *Recently patched. Cracking visible in SB ETW at N. end. Cracking visible at S. end to NB ETW. Active with high surf, road realigned toward headscarp in 2/98.*	OP	TL	59, 60	Topo map 3 Aerial map 12
Willow Springs Maintenance Station to Mill Creek Bridge	32	X						PM 13.31	PM 13.35	50	8m, 48° Below	Fill over Marine Terrace Deposits		X		*Embankment failure. Cracking visible at S. end but not at N. end if slide. Recently repotted. Sag along CL at middle.*	P	OL	61, 62	Topo map 3 Aerial map 13
	33	X						PM 17.23	PM 17.23	10	25m, 43° Below	Fill over Colluvium	X	X	1/97 EO	*Continuous cracking in roadway into center of SB lane. No cracking visible at EP.*	NP	OL	63, 64	Topo map 4 Aerial map 15
	34	X						PM 17.75	PM 17.75	80	45m, 33° Below	Fill over KJf		X	1/97 EO 2/98 EO	**(Wild Cattle Creek)** *No Cracking Visible. Head of slide unloaded in 2/1998, no activity since.*	NP	B	65, 66	Topo map 4 Aerial map 16
PM 10.42 to 18.46	35	X						PM 19.85	PM 19.86	12	45m, 45° Below	Fill	X	X	2/00 ER	*Plugged culvert inlet 2/00. Cracking at S. end of Embankment. Slope undermined by pipe jacking outlet pit.*	P	OL	67, 68	Topo map 4 Aerial map 17
	36	X						PM 20.79	PM 20.85	95	25m, 42° Below	Fill, KJf and Metamorphics (Schist)		X		*Cracking across both lanes behind S. T-wall @ cut/fill contact.*	NP	TL	69, 70	Topo map 4 Aerial map 18
Monterey County Highway 1	37	X	X	X				PM 21.44	PM 21.57	170	90m, 40° Above/ 69m, 40° Below	Metamorphic (Schist) above, Fill below	X	X	1/97 EO 2/98 EO 1/99 EO 2/00 ER	**(Pitkin's Curve)** *Repaired and realigned behind headscarp after 2/2000. Slump and debris flows. Numerous failures in new cut @ N, springs above and below road.*	N/A	TL	71 to 74	Topo map 5 Aerial map 19

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Segment Name, Endpoints and Stationing	Loc. No.	Landslide	Debris Flow/Mudflow	Rock Fall	Surface Sloughing	Flood	Other	From	To	Along Highway Length (meters)	Slope Distance, Angle[2]	Primary Geologic Units[3]	Shallow Ground-water[4]	Extends Beneath Hwy			Road Condition	Roadbed Impact		
Mill Creek Bridge to Lucia	38	X		X				PM 21.70	PM 22.12	480		Fill, KJf	X	X	Frequent 1995 1/99	**(Big Slide)** *Cracking visible into CL w/ noticeable sag across roadway. At PM 22.00 (just to the N.) cracking visible along CL. Prominent scarp below roadway, springs above roadway.*	P	A/B	75, 76	Topo map 5 Aerial map 19
	39	X						PM 21.92	PM 22.08	55 S. Slide 50 N. Slide	65m, 45° South/ 40m, 43° North	Fill, KJf	X	X	1/99 2/00 (K-rail placed)	*Failure below road within limits of Big Slide. Cracking and Sag exists across entire roadway on both limits on the N. Slide. Erosion to the ETW of the SB lane on the S. Slide with visible cracking at the N. end.*	OP OP	OL A/B	77, 78	Topo map 5 Aerial map 19
PM 18.46 to 23.00	40	X						PM 22.69	PM 22.96	430		KJf	X	X	Frequent 1/97 2/98 1/99 2/00	**(Dani Creek)** *Very complex cracking. Scarp runs in and out of roadway on the SB side. Sections also run into the NB lane, and up into the mountain near the driveway.*	OP	A/B	79, 80	Topo map 5 Aerial map 20
Monterey County Highway 1	41	X						PM 23.06	PM 23.06	15	12m, 33° Below	Fill over KJf	X	X		*Possible culvert failure beneath roadway. Sag and cracking cross entire roadway above culvert. Recently patched.*	P	TL	81, 82	Topo map 5 Aerial map 21
Lucia to Big Creek Bridge	42	X		X	X			PM 23.11	PM 23.26	210	80m, 22° Below	KJf	X	X	2/98 EO 1/99 2/00 Continued creep with cracking and patching.	**(Grampa's Elbow)** *from the S. cracking and sag starts in SB shoulder, then continues into the roadway to the and runs along the NB shoulder before returning to the SB shoulder at the N. end. 2/98 failure of interslice with large soil/rock slump with toe in ocean. Road realigned into cut with local material, numerous springs above road. Earth flows in 1/99.*	OP	TL	83, 84	Topo map 5 Aerial map 21
PM 23.00 to 28.09	43	X						PM 23.27	PM 23.27	20	26m, 32° Below	Fill	X	X	2/98 EO	*Possible culvert failure beneath roadway. Cracking and sag into SB lane of roadway above culvert. Recently patched. Constructed fill with wet material.*	P	OL	85, 86	Topo map 5 Aerial map 21

Table A-1
CHMP SUMMARY OF EXISTING AND POTENTIAL SLOPE INSTABILITY SITE CHARACTERISTICS
Highway 1-San Carpoforo to the Carmel River Bridge

General Area		Type of Potential Unstable Condition						Approximate Stationing at Highway[1]			Hazard Area Characteristics				Documented Period of Activity	Notes and Special Conditions[5]	Landslide Effects Matrix[6]		Photos	References[7]
Segment Name, Endpoints and Stationing	Loc. No.	Landslide	Debris Flow/Mudflow	Rock Fall	Surface Sloughing	Flood	Other	From	To	Along Highway Length (meters)	Slope Distance, Angle[2]	Primary Geologic Units[3]	Shallow Ground-water[4]	Extends Beneath Hwy			Road Condition	Roadbed Impact		
	44	X						PM 23.63	PM 23.85	360	120m, 30° Above/ 130m, 33° Below	KJf, Qols	X	X		*Part of very large landslide. 8cm sag across entire roadway at N. end. At S. end roadway recently repatched w/ cracking across entire roadway.*	P	A/B	87, 88	Topo map 5 Aerial map 21
	45	X						PM 24.80	PM 24.95	200	170m, 25° Above/ 250m, 19° Below	KJf	X	X		*Two large cracks with sags across roadway at N. end. At S. end several cracks are visible across the roadway, slide extends up drainage. 1.2m of fill placed to raise roadway grade (disposal).*	P	A/B	89, 90	Topo map 6 Aerial map 22
	46	X						PM 24.99	PM 25.26	130	150m, 31° Below	KJf	X	X	1/97 2/98 EO	*Road realigned off of landslide. Recession of head scarp below road.*	NP	B	91, 92	Topo map 6 Aerial map 22
	47	X						PM 26.13	PM 26.26	65	120m, 33° Above/ 110m, 39° Below	Qols		X	1/97 2/98 EO	**(N. Vicente Creek)** *Sag and cracking along CL in SB lane above destroyed crib wall in 1980's. Recently repatched. At N. end Larger slide exists across roadway w/ sag and cracking in both lanes. Road reprofilled in 1998.*	OP	A/B	93, 94	Topo map 6 Aerial map 23
	48	X						PM 26.40	PM 26.40	50	120m, 42° Below	Fill over KJf		X		*Sag along guardrail in SB lane. Cracking not visible under patch.*	P	OL	95, 96	Topo map 6 Aerial map 23
	49	X						PM 26.80	PM 26.80	40		Qols	X		2/98 EO	*Soil slump, need to grade ditch to drain.*	N/A	A	97, 98	Topo map 6 Aerial map 24
	50	X						PM 27.0	PM 27.3	500		Qols		X		*Noticeable dip in roadway*	NP	A/B	99, 100	Topo map 6 Aerial map 24
	51	X						PM 27.47	PM 27.63	300	250m, 18° Above/ 100m, 41° Below	Colluvium over KJf, Qols	X	X		*Cracking and sag across entire roadway along S. end above reprofile (2000). Cracking and sag visible along N. end above reprofile (2000) in SB lane.*	P	TL	101, 102	Topo map 6 Aerial map 24
	52	X		X				PM 27.85	PM 28.04	160	293m, 44° Above/ 100m, 30° Below	KJf, Qols		X	2/98 2/00 ER	*Rockslide above road in 2/2000, material disposal adjacent to and below road. N. and S. sections of the road have major cracking and Sag.*	N/A	A/B	103, 104	Topo map 6 Aerial map 24

Table A-1
CHMP SUMMARY OF EXISTING AND POTENTIAL SLOPE INSTABILITY SITE CHARACTERISTICS
Highway 1-San Carpoforo to the Carmel River Bridge

General Area		Type of Potential Unstable Condition						Approximate Stationing at Highway[1]			Hazard Area Characteristics				Documented Period of Activity	Notes and Special Conditions[5]	Landslide Effects Matrix[6]		Photos	References[7]
Segment Name, Endpoints and Stationing	Loc. No.	Landslide	Debris Flow/Mudflow	Rock Fall	Surface Sloughing	Flood	Other	From	To	Along Highway Length (meters)	Slope Distance, Angle[2]	Primary Geologic Units[3]	Shallow Ground-water[4]	Extends Beneath Hwy			Road Condition	Roadbed Impact		
Monterey County Highway 1	53			X				PM 28.30	PM 28.52	150	200m, 41° Above	KJf				**(Cow Cliffs)** *Rockfall above road.*	N/A	A	105, 106	Topo map 6 Aerial map 25
	54	X		X				PM 29.46	PM 29.47	100	165m, 44° Above	Colluvium	X		2/98 EO	**(Wing Gulch)** *Landslide above road (Regraded in 1998)*	N/A	A	107, 108	Topo map 6 Aerial map 26
	55	X						PM 30.15	PM 30.15	20	40m, 35° West/ 20m, 48° East	Fill	X	X		*Embankment across drainage. Cracking visible to CL.*	NP	OL	109, 110	Topo map 6 Aerial map 26
Big Creek Bridge to Julia Pfeiffer Burns State Park	56	X						PM 30.24	PM 30.25	40	100m, 41° Below	Fill over Colluvium?	X	X		**(Rancho Barranca)** *Cracking and sagging visible into center of SB lane. Very green vegetation (8-8-00).*	NP	OL	111, 112	Topo map 6 Aerial map 26
	57	X						PM 31.55	PM 31.55	50	23m, 35° Below	Fill over Marine SS		X		*Cracking parallel to center of SB lane. Sag @ S. end of '86 geogrid reinforced wall.*	NP	OL	113, 114	Topo map 7 Aerial map 27
PM 28.09 to 45.58	58	X						PM 35.08	PM 35.15	100	35m, 33° Below	Fill over Sur Series Meta-SS, and Cenglomerate	X	X		*Two separate adjoining slides. S. Slide cracking visible across roadway. N. end Cracking also visible across roadway.*	P	TL	115, 116	Topo map 7 Aerial map 30
Monterey County Highway 1	59	X						PM 36.25	PM 36.25	100	198m, 40° Below Viaduct	Fill from J.P. Burns Slide		X		*Erosion of McWay Slide Debris to near the edge of the 1997 J.P. Burns Viaduct.*	N/A	B	117, 118	Topo map 8 Aerial map 31
	60	X						PM 36.43	PM 36.43	50	55m, 40° Below	Fill		X	2/98 ER	*Erosion of slope. No cracking visible (road recently repatched). Tieback wall under construction 10/20.*	P	OL	119, 120	Topo map 8 Aerial map 31
Julia Pfeiffer Burns State Park to Pfeiffer Canyon Bridge	61	X		X				PM 38.95	PM 38.95	25	37m, 42° Below	Fill over Sur Series Metasediments		X		*No Cracking visible in roadway, sag and bend in guardrail.*	P	OL	121, 122	Topo map 8 Aerial map 33
	62	X		X				PM 39.00	PM 39.00	30	70m, 43° Below	Sur Series Marble		X		*Cracking visible on S. side into NB lane. No cracking visible in roadway at N. end*	P	TL	123, 124	Topo map 8 Aerial map 33
PM 35.84 to 45.58	63	X						PM 40.80	PM 40.80	80	124m, 41° Below	Fill over Qtz Diorite		X		*Cracking visible at N. end across roadway. No cracking visible at S. end in front of Coast Gallery*	NP	TL	125, 126	Topo map 9 Aerial map 34, 35
	64							PM 42.56	PM 42.56	28	59m, 37° Below	Fill over Sur Series Metosediment	X	X		*Under pine trees, cracking in SB lane to CL. Recent Patch offset.*	OP	OL	127, 128	Topo map 9 Aerial map 36

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Highway 1-San Carpoforo to the Carmel River Bridge

General Area		Type of Potential Unstable Condition						Approximate Stationing at Highway[1]			Hazard Area Characteristics				Documented Period of Activity	Notes and Special Conditions[5]	Landslide Effects Matrix[6]		Photos	References[7]
Segment Name, Endpoints and Stationing	Loc. No.	Landslide	Debris Flow/Mudflow	Rock Fall	Surface Sloughing	Flood	Other	From	To	Along Highway Length (meters)	Slope Distance, Angle[2]	Primary Geologic Units[3]	Shallow Ground-water[4]	Extends Beneath Hwy			Road Condition	Roadbed Impact		
	65	X						PM 42.70	PM 42.70	33	50m, 35° Below	Fill over Sur Series		X		*Cracking behind crib wall to CL of road. Slight sag in guardrail.*	NP	OL	129, 130	Topo map 9 Aerial map 36
	66	X						PM 42.92	PM 42.92	30	35m, 48° Below	Fill over Decomposed Qtz Diorite		X		*Cracking visible into center of SB lane. Guardrail sags @ center of slide.*	NP	OL	131, 132	Topo map 9 Aerial map 36
	67	X						PM 44.40	PM 44.40	55	80m, 42° Below	Fill over Qols, KJf	X	X		*No cracking in roadway visible. Erosion of headscarp. Piezometer installed in center of SB lane. Retaining wall to be constructed 2000-01.*	N/A	B	133, 134	Topo map 9 Aerial map 37
	68	X						PM 44.81	PM 44.81	30	16m, 35° Below	Fill, Qols, KJf	X	X	1/97 2/98	**(Crescent)** *Cracking in road to CL. Recently patched.*	OP	OL	135, 136	Topo map 9 Aerial map 37
	69	X						PM 44.90	PM 44.93	70		Qols, KJf	X	X	1/97 2/98	**(Post Ranch)** *Cracking w/ patch on roadway.*	OP	A/B	137, 138	Topo map 9 Aerial map 37
Monterey County Highway 1	70	X						PM 51.12	PM 51.12	60	22m, 34° Below	Fill over SS	X	X		**(Andrew Molera)** *Cracking visible to CL of road.*	NP	OL	139, 140	Topo map 11 Aerial map 43
	71	X						PM 51.55	PM 51.55	10	25m, 40° Below	Fill		X		*Cracking and sag on roadway to ETW*	NP	OL	141, 142	Topo map 11 Aerial map 43
Pfeiffer Canyon Bridge to Little Sur River Bridge	72	X						PM 54.48	PM 54.48	40	10m, 38° Below	Fill over Marine Terrace Deposits		X		*Cracking along center of SB lane.*	NP	OL	143, 144	Topo map 11 Aerial map 46
PM 45.58 to 56.10	73	X						PM 54.86	PM 54.90	45	32m, 41° Below	Fill		X		*Erosion below roadway. Cracking in SB lane at N. and S. ends.*	NP	OL	145, 146	Topo map 12 Aerial map 46
	74	X						PM 54.93	PM 54.93	40	34m, 26° Below	Marine Terrace Deposits over Sandstone				*Erosion above road. Slide deposits at edge of NB shoulder.*	N/A	A	147, 148	Topo map 12 Aerial map 46
	75	X						PM 55.01	PM 55.01	63	17m, 32° Above	Marine Terrace Deposits				*Erosion above road. Slide deposits at edge of NB shoulder.*	N/A	A	149, 150	Topo map 12 Aerial map 46
	76	X						PM 55.22	PM 55.22	15	53m, 45° Below	Sandstone over Marine Terrace Deposits		X		*Erosion at Box Culvert within 1m of EP in SB lane.*	N/A	B	151, 152	Topo map 12 Aerial map 46
	77	X						PM 55.87	PM 55.87	17	47m, 26° Below	Fill over Sandstone		X		*Recently repatched. Cracking into SB lane.*	P	OL	153, 154	Topo map 12 Aerial map 47

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Highway 1-San Carpoforo to the Carmel River Bridge

General Area		Type of Potential Unstable Condition						Approximate Stationing at Highway[1]			Hazard Area Characteristics				Documented Period of Activity	Notes and Special Conditions[5]	Landslide Effects Matrix[6]		Photos	References[7]
Segment Name, Endpoints and Stationing	Loc. No.	Landslide	Debris Flow/Mudflow	Rock Fall	Surface Sloughing	Flood	Other	From	To	Along Highway Length (meters)	Slope Distance, Angle[2]	Primary Geologic Units[3]	Shallow Ground-water[4]	Extends Beneath Hwy			Road Condition	Roadbed Impact		
	78	X						PM 55.92	PM 55.92	40	60m, 27° Below	Fill over Qls		X		*No visible cracking under patch. Slide extends into NB lane.*	P	TL	155, 156	Topo map 12 Aerial map 47
	79	X						PM 56.00	PM 56.00	20	14m, 23° Above	Marine SS, Qols				*Landslide above roadway.*	N/A	A	157, 158	Topo map 12 Aerial map 47
Monterey County Highway 1	80	X						PM 56.35	PM 56.40	50	50m, 39° Below	Fill over Sandstone		X		*Cracking visible to CL @ N. end. No patch, toes at Little Sur River.*	NP	OL	159, 160	Topo map 12 Aerial map 47
Little Sur River Bridge to Yankee Pt. Dr.	81						X	PM 57.33	PM 57.33	22	90m, 46° Below	Sandstone and Conglomerate		X		**(Straight Down)** *Erosion within 1.2m of shoulder. Wind blowing back culvert discharge is undercutting the shoulder. Culvert bypassed in 2000.*	N/A	B	161, 162	Topo map 12 Aerial map 47
	82	X						PM 57.44	PM 57.44	45	39m, 45° Above/ 105m, 32° Below	Sur Series over Sandstone	X	X		*Erosion 2m from shoulder. Roadway realigned into cut. Water pooling at base of headscarp*	N/A	B	163, 164	Topo map 12 Aerial map 47
PM 56.10 to 67.34	83						X	PM 57.90	PM 58.30	30	87m, 38° Above/ 200m, 35° Below	Sur Series over Metased. (limestone), sandstone	X	X	2/98 EO 1/99 EO	**(Hurricane Point)** *Landslide removed roadbed. Road realigned into cut in 2/98. Erosion of supporting cliff @ N. end within 8m of EP.*	N/A	B	165, 166	Topo map 12 Aerial map 48
	84	X	X					PM 59.59	PM 59.59	16	70m, 42° Below	Fill Over Colluvium		X		*Head Scarp within 1.3m of EP, old debris flow failure, no cracking in roadway.*	NP	B	167, 168	Topo map 12 Aerial map 49
	85						X	PM 59.75	PM 59.75	35	100m, 44° Below	Marine Terrace Deposits over Sandstone		X		*Erosion to MBGR, Three posts exposed*	N/A	B	169, 170	Topo map 13 Aerial map 49
	86	X						PM 62.16	PM 62.16	27	24m, 42° W. Side	Fill	X	X	2/98 EO	*Cracking in SB shoulder. Upstream culvert has a stand pipe. Steep embankment w/ sag. Reconstructed w/ geogrid.*	NP	B	171, 172	Topo map 13 Aerial map 51
	87	X						PM 64.28	PM 64.28	50	35m, 28° Above/ 32m, 36° Below	Qls over quartizdiorite	X	X		*No patch, water seeping on NB shoulder. Sag in MBGR. Cracking to NB lane.*	NP	TL	173, 174	Topo map 13 Aerial map 52
	88	X						PM 66.18	PM 66.18	25	35m, 41° West/ 11m, 39° East	Fill			2/98 EO	*Culvert outlet failed in 2/98, partial reconstruction of embankment on SB side, evidence of inadequate compaction on fill face.*	OP	TL	175, 176	Topo map 13 Aerial map 53

Notes:

(1) Stationing estimated between postmile stations, at key landmarks and intersections
(2) Maximum vertical height dimension of feature relative to highway level.
(3) Geologic units obtained from published geologic maps. Units defined as follows:

Colluvium	Loose incoherent deposits, usually at the foot of a slope or cliff and brought there chiefly by gravity. Talus and cliff deposits are included in such deposits.
Conglomerate	Course-grained clastic sedimetarty rock, composed of rounded to subangular fragments larger than 2mm in diameter (granules, pebbles, cobbles, boulders) set in a fine-grained matrix of sand or silt, and commonly cemented by calcium carbonate, iron oxide, silica, or hardened clay; the consolidated equivalent of gravel
Diorite	Group of plutonic rocks intermediate in composition between acidic and basic, characteristically composed of hornblende, oligoclase or andesine, pyroxene, and sometimes a small amount of quartz.
Fill	Man made deposits of rock, soil, tailings, or the like, used for building embankments or highway grades.
KJf:	Franciscan Formation,
Limestone	Sedimentary rock consisting chiefly of mineral calcite, with or without magnesium carbonate. Common impurities include chert and clay. It yields lime on calcination.
Marble	Metamorphic rock consisting predominately of fine to course grained recrystallized calcite and/or dolomite.
Marine Terrace	Narrow coastal strip, formed of deposited material, sloping gently seaward. Or a wave-cut platform that has been exposed by uplift along a seacoast or by lowering of sea level.
Metasediment	A sediment or sedimentary rock that shows evidence of having been subjected to metamorphism.
Q_{ols}:	Old landslide material. Comprised of rock mudflow debris that moved downslope by gravity. Lithology dependent on source material.
Quartz Diorite	Plutonic rocks having the composition of diorite but with an appreciable amount of quartz.
Sandstone	A clastic sedimentary rock composed of grains of sand size set in a matrix of silt or clay and more or less firmly united by cementing material (commonly sislicam iron oxide, or calcium carbonate); the consolidated equivalent of sand.
Schist	Strongly foliated crystalline rock, formed by dynamic metamorphism, that has well developed parallelism of more than 50% of the minerals present, particularly those of lamellar or elongate prismatic habitat.
SS	Sur Series

(4) Areas where mapped seeps, well data of abundant phreatophytes indicate the presence of a near-surface groundwater.
(5) Regular text indicates information from cited reference(s); *observations from current investigation shown in italics.*

(6) Landslide Effects Matrix:

Road Condition

Class		Description Criteria (as of 7/00-9/00)
NP	No Patch	No patch on roadway
P	Patch	Patch on roadway
OP	Offset Patch	Patch w/offset on roadway
N/A		Not Applicable

Proximity to Roadbed or Roadway Impact

Class		Description Criteria
A	Slide Above	Landslide Limited to Slope Above Roadway
B	Slide Below	Landslide Limited to Slope Below Roadway
AB	Above and Below	Landslide Involves Slope Above Roadway, Both Lanes, Slope Above Roadway
OL	One Lane	Failure Impacts One Lane and Slope Below Roadway
TL	Two Lanes	Failure Impacts Two Lanes and Slope Below Roadway

(7) See main text for list of references.

Abbreviations:

CL: Centerline
E: East
EO: Emergency Opening
EP: Edge of pavement
ER: Emergency Restoration
ETW: Edge of Travel Way
L/S: Landslide
N: North
NB: Northbound
RX: Rocks
S: South
SB: Southbound
W: West